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COMPARATIVE ANALYSIS FOR THE DEPLOYABLE WATERFRONT

ABSTRACT This report defines the deployable waterfront facility (DWF) concept and identifies existing systems that are useful for comparing the integrated logistics support (ILS) requirements and operation and support costs of these systems. A baseline comparison system (BCS) for the DWF will be developed which represents the system's characteristics and capabilities. The BCS will be used to identify the supportability, cost, and readiness drivers of the system and to project its reliability, maintainability, and availability characteristics. A framework will be established for conducting the ILS and cost comparisons. The scenario describes the personnel and support equipment requirements, duty cycle, equipment life, and a description of four missions in which the systems are compared.

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SECTION 1

INTRODUCTION

1.1 BACKGROUND

Supplying the material and equipment necessary to build-up and support amphibious and advanced base operations is a large task. Facilities for ship offloading including deep draft piers and a logistics-over-the-shore (LOTS) capability must be brought into productive service early on in an operation. Currently, this capability is provided by the Navy's ship-to-shore (S-T-S) LOTS system of lighters, ferries, and floating docks, as well as a multitude of similar barge-like floating and jack-up piers. In recent history, similar large modular structures have provided this capability.

During World War II, the prefabricated Mulberry Port was towed across the English Channel and rapidly installed in Normandy, France to support advanced base operations. It was designed to handle 12,000 tons of cargo and 2,500 vehicles per day. The Mulberry port consisted of a jack-up pier head, connected to shore by a floating roadway. A breakwater was constructed to shelter the facility from waves and current at the unprotected beach.

During the Vietnam War, the DeLong barge units were used extensively to provide deep water berths in sheltered waters during the 1965-66 build-up. A total of seven piers were constructed from the DeLong barge units at a total cost of approximately \$100M (in 1966 dollars, not including dredging and shoreside construction). The piers ranged in length from 600

to 1,200 feet and provided covered, open, and refrigerated storage, maintenance facilities, hospital beds, and housing.

Much more recently, the British Navy employed the Flexiport facility in the Falkland Islands to support after action operations. The Flexiport facility (which is marketed commercially) consisted of six 90'x300' offshore oilfield barges 'connected to shore by 600' of ballasted causeway. They were outfitted in England and transported the 8,000 miles by heavy lift semi-submersible ship. The facility was located in a sheltered environment. On-site construction took approximately 75 days and once operational, the facility provided 900 feet of ship berthing, 1.27M cubic feet of covered storage, 18,000 square feet of quayside work area, a heliport, and a Roll-on/Roll-off (Ro/Ro) facility, at a total cost of approximately \$32M.

These and other systems have provided 'satisfactory ship unloading, and other Fleet support services as an adjunct to strategic sealift operations. The current Navy over-the-beach systems get the job done but are manpower and equipment intensive and quite inefficient. The modular port facilities (DeLong with roadway) will support lighter and causeway ferry operations but cannot sustain ship berthing loads above Sea State 1 . A system is needed that can be rapidly transported to any worldwide contingency area and interface with an unprotected beach and/or a quay wall in a protected harbor, depending on the mission. Appropriately outfitted, it must have the capability to support cargo operations (breakbulk, containerized, and vehicular), naval ship homeport, and troop support services. The deployable waterfront (DWF) is currently being investigated for its feasibility and cost effectiveness in providing these mission capabilities.

1.2 SCOPE

This report will define the DWF concept and identify existing systems which are useful for comparing the Integrated Logistic Support (ILS) requirements and operation and support (O&S) costs of these systems. A baseline comparison system (BCS) for the DWF will be developed which represents the system's characteristics and capabilities. The BCS will be used to identify the supportability, cost, and readiness drivers of the system and to project its reliability, maintainability, and availability (RM&A) characteristics. A framework will be established for conducting the ILS and cost comparisons. The scenario will describe the personnel and support equipment requirements, duty cycle, equipment life, and a description of four missions in which the systems are compared.

1.3 SUMMARY

The Deployable Waterfront (DWF) is a relocatable pier system designed to facilitate cargo operations and provide Naval ship berthing services in the continental United States (CONUS) and/or abroad. The DWF is made up of large (100'x300') barge-like deployable pier units (DPUs). The DPUs will probably have a double deck configuration for increased productivity and can be outfitted with pre-fabricated warehouse, office, shop, and utility facilities in order to accommodate the different ship Classes in a variety of missions. Several DPUs, joined end to end with a connecting roadway to shore, and suitably outfitted for that particular mission, make up the DWF. The DPUs will float to aid the transportability and assembly, and can either float, be jacked up, or bottom seated to perform the mission.

The DPUs and their support equipment will be carried to the objective area by heavy lift semi-submersible ships or towed (on its own hull or carried on heavy lift barges) by ocean going tug.

Once on-site and offloaded, tugs will maneuver the DPUs into position. They will be joined and then the system will be moored in place. Mooring methods under consideration are jack-up , floating with tension leg anchor , or pile restrained. Suitable fenders and other protective systems must be developed in order to permit the DWF to operate in sea state four (SS 4).

There are four missions which are analyzed herein for the DWF. These missions will later be compared to a complementary mission with an existing system. Each mission provides a unique asset and service facility to the Fleet. The objectives of the four missions are as follows:

Mission 1 - Increased LOTS Throughput Capability. In this mission, the DWF will be installed at an unsheltered beach and must provide a cargo on/offload facility for commercial and military ships and must be able to sustain operations in SS 4.

Mission 2 - Prepositioned Materiel Site Support. In this mission the DWF will be used for initial loading out, recycling, and outloading (upon mobilization) at prepositioned storage sites. In the interim, the DWF can be used by the host nation as part of an agreement for the use of the site.

Mission 3 - Advanced Logistic Support Base. In this mission, the DWF will act as a mobile cargo terminal for the Navy's Mobile Logistic Support Force. The DWF would be required to support shuttle ship cargo transfer, cargo consolidation, provide a staging area and a storage site.

Mission 4 - Naval Ship Berthing. In this mission, the DWF will provide mobile homeport facilities and

services to the Fleet. This could be to augment damaged Naval bases in CONUS or to support Fleet operations abroad.

The existing systems to which the DWF will be compared in these four missions are as follows:

Mission 1

The DWF (plus fenders and a mooring system suitable to sustain operations in SS 4) will be compared to the existing S-T-S LOTS system of lighters, landing craft, causeways, and ferries which comprise the Navy's present over-the-beach system.

Mission 2

The DWF will be compared to a standard fixed pier.

Mission 3

The DWF (plus modular warehouse and storage structures) will be compared to a fixed pier similarly equipped.

Mission 4

The DWF (plus utility supply systems and a limited ship repair capability) will be compared to a fixed pier similarly equipped.

In each mission, the two systems compared have equivalent throughput capacity and ship service capabilities.

The baseline comparison system for the DWF that is used in these comparisons is made up of four DPUs and a suite of common

equipment. This support equipment includes ramps, mobile container cranes, a mooring system, fenders, forklifts, lights and generators, trucks, and an administration office. Additional unique support equipment is specified where it is necessary to support special mission requirements. For Mission 1, this means a special SS 4 mooring and fendering system; for Mission 3, additional storage and warehouse space; and for Mission 4, utility supply and ship repair equipment. The cost of this support equipment is estimated for the cost analysis.

The supportability, cost and readiness drivers that are identified for this BCS are as follows:

DPU Size - Smaller units will simplify transportation and increase configurational flexibility, possibly at the cost of stability and overall cost.

Construction Material - Maintenance requirements of steel will be higher than reinforced concrete construction. Also, concrete construction will yield longer life.

Environmental Capability - SS 4 appurtenances will significantly increase complexity, cost and support requirements.

Procurement/Ownership Options - Significant cost savings can be realized if peacetime utilization of the DWF by commercial interests is achieved.

Method of Transportation - Heavy lift ship transportation is faster (16 kts max), safer and somewhat more costly than towing (4-6 kts). Mobility and readiness are impacted as a result.

Configuration - Double deck DPUs will save space and be more productive at about the same cost as a single deck unit.

Not surprisingly, most of these factors have a high impact on cost. Cost will be affected to some degree by all six of these factors and others. Readiness is also affected by most of these factors, particularly the environmental capability and transportation method. The effect of any one factor is difficult to isolate, however, as for example, the DPU size may dictate the method of transportation and at the same time determine the attractiveness to commercial interests.

The RM&A characteristics of the DWF cannot be quantified at this point, though a general assessment can be made. In Missions 2, 3, and 4 with the DWF as a floating system, its RM&A characteristics are predicted to be superior to those of a fixed pier. If the DWF is a jack-up system, the RM&A characteristics may decline due to the added complexity of the elevating mechanism. The manpower required for operation of the pier will be the same of both the DWF and the fixed pier. This applies to mooring of ships along side, ship repairs, repairs to the structure itself as well as maintenance of the support equipment. In Mission 1, the DWF is predicted to have reliability and maintainability characteristics far superior to the S-T-S LOTS system of equipment. An important factor is that the S-T-S LOTS system is composed of a large collection of mechanical equipment which have high maintenance requirements and failure rates because of the harsh environment in which they must operate.

The availability of the S-T-S LOTS system is boosted by its built in redundancy and flexibility but this may be offset by its severe sea state limitations. The DWF on the other hand is less susceptible to failure and even if damaged can probably sustain some limited throughput operations.

The ILS requirements comparison yielded no surprises. The three systems are compared in the four mission scenarios. In most support areas, particularly manpower and personnel, maintenance, supply support, support and test equipment, and training, the requirements of the S-T-S LOTS system are significantly higher than the DWF. The reasons for this are again because of the quantity and variety of heavy mechanical equipment in the S-T-S LOTS system. The DWF requirements are about the same as for the fixed pier. For the DWF, the potentially complex mooring and fendering system and lesser stability and sturdiness as compared to the fixed pier may contribute to the ILS needs. The requirements for technical documentation, computer resources, facilities, and packaging, handling, storage, and transportation are much less significant for all the systems compared. One notable exception is transportation. The unique transportation requirements of the DWF make this a critical support area.

For the cost comparison, the O&S costs for each system were estimated based on a 25 year life, divided between 24-1/2 years of peacetime and 6 months of wartime operation. The cost model specified the man-hours of operation, labor rate, fuel cost, and other pertinent factors for each system. The basic manufacturing hardware cost was first estimated and then served as an important determinant of its O&S costs (Reference 1). All costs are in 1987 dollars. Table 1-1 summarizes the results of the cost analysis and Appendix A contains the raw data.

The O&S cost elements considered are personnel, consumables, maintenance, modifications, and support equipment replacement. For the DWF the manufacturing hardware cost for Mission 1 is almost double that of the other three missions. This is due to the extra cost of special mooring, fendering, and roadway systems that are required to support that mission. The initial cost of the fixed piers does not vary from mission to mission by more

than 25 percent. The cost of the S-T-S LOTS system is the greatest by far at \$275M.

Table 1-1. Cost Comparison Summary (M\$)

		Manufacturing Hardware Cost	Total O&S Costs*
Mission 1 LOTS	DWF	55	129
	S-T-S LOTS	264	4,746
Mission 2 Preposition	DWF	23	36
	Fixed Pier	20	33
Mission 3 ALSB	DWF	27	135
	Fixed Pier	21	134
Mission 4 Homeport	DWF	30	63
	Fixed Pier	25	44

* See Appendix A and section 2.7 for detailed description of cost model and methodology.

For all the systems, the greatest contributors to O&S costs are personnel and consumables. Not surprisingly, fuel cost is the most significant contributor to the cost of consumables. This is especially true of the S-T-S LOTS system. The personnel costs of this system are also significantly higher, consistent

with the number and variety of personnel, required to satisfy the S-T-S LOTS mission requirements. When total O&S costs are considered, Mission 1 is the most costly to carry out; \$107M for the DWF and \$5,235M for the S-T-S LOTS system. For Missions 2, 3, and 4, the O&S costs for the DWF are about the same. The similarity in costs of these two systems is expected and is insignificant when taken over the life of the systems. The cost savings that is realized when the DWF is moved (due to mission or political reasons) is equal to the cost of an equivalent fixed pier at that location.

1.4 CONCLUSIONS

The DWF can provide some very essential services to the Fleet in a relatively cost effective manner. The O & S costs, ILS requirements, and RM&A characteristics compare favorably with existing systems when the advantages and attendant risks associated with its development are considered.

The O & S costs of the DWF were found to be significantly less than the S-T-S LOTS system and only slightly greater than those of the fixed pier for the missions in which they were compared. Because of the distinct advantages of the DWF over these current systems, it is concluded the DWF is a cost effective alternative to the existing systems.

The logistic support requirements of the DWF were found to be less than the S-T-S LOTS system and not significantly different than a fixed pier for like operations. Because the DWF is compared to a fixed pier for three of four missions, it is concluded that the DWF support requirements can be met without placing a significant burden on the Navy logistics support system.

The RM&A characteristics of the DWF are much better than the S-T-S LOTS system and slightly better than those of a fixed pier. Though these conclusions are based on a qualitative assessment, they suggest that the DWF is a feasible system that can effectively provide the required operational assets.

The development risk associated with the DWF for the SS 4 system is moderate and for the other three missions, the risks are minimal. It is concluded that the DWF is a feasible and cost effective system when compared with its alternatives. The support requirements are reasonable and can be met within the existing Navy system.

The DWF has some distinct advantages over the existing systems and can be an important tool for supporting the Navy mission of Strategic Sealift, Assault Follow-on, and power projection.

This Comparative Analysis only considers the O & S costs when making comparisons. Investment costs are not included. To determine the actual costs for comparison at a given time, consideration would have to be given to those assets already on hand.

SECTION 2

DISCUSSION

2.1 DEPLOYABLE WATERFRONT DESCRIPTION

The Deployable Waterfront is a system designed to facilitate the delivery of logistic and fleet support services to U.S. forces in the continental United States and abroad. The system consists of reconfigurable deployable pier units (DPUs) which can be outfitted with special modules to support various missions.

2.1.1 PHYSICAL DESCRIPTION

Each DPU will be approximately 300' long, 100' wide and resemble a large floating barge. The DPUs will be constructed of reinforced concrete or steel and will contain buoyancy chambers to provide flotation (Figure 2-1). The DPUs will probably be designed with a double deck configuration for increased productivity (Reference 3).¹ The roof of the buoyancy chamber will form the deck of the lower level and the roof of the lower level will form the deck of the upper level. Utility supply lines, machinery, and material that clutters a conventional pier can be supplied from the lower level. The upper deck will remain clear so that vehicles, maintenance crews, and cargo operations can proceed unhindered. In this way, ships can be serviced

¹The Navy recently constructed its first double deck pier; Pier Zulu, Charleston Naval Station, S.C., with very favorable results. Pier Zulu is 1245' long with a 70' wide upper deck and 75' lower deck. All utilities (steam, water, compressed air, electricity) are supplied to ships from the lower deck, leaving the upper deck clear and unobstructed for vehicles and work crews. Navy cost comparisons show that the double deck pier costs \$8,000 per linear foot and a single deck pier costs \$11,300 per linear foot. The standard 120' wide single deck pier also suffers the disadvantage of occupying significantly greater (and in some locations, vital) ship maneuvering space.

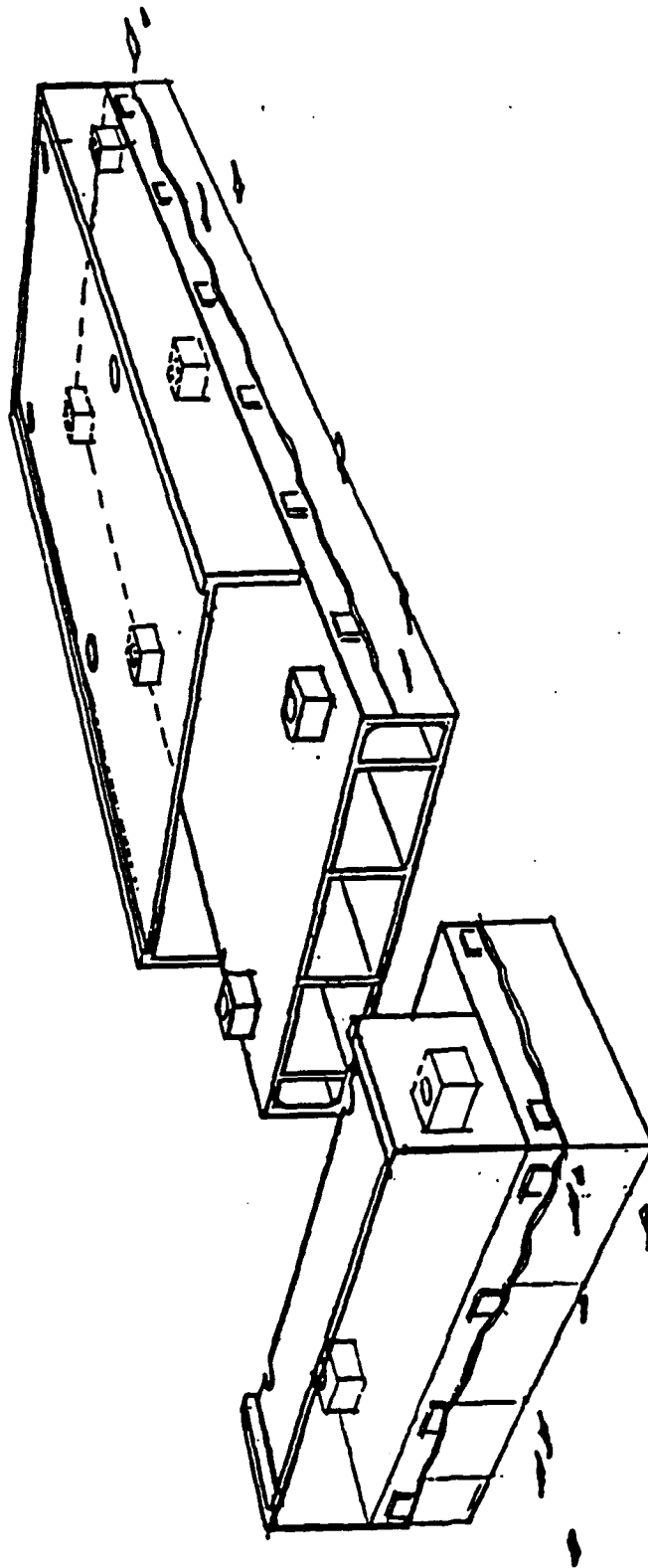


Figure 2-1. Floating Double Deck Module. (Reference 2)

and unloaded simultaneously without the interference, confusion and crowding which is characteristic of standard piers . The lower deck will also provide readily accessible covered storage.

The DPUs will be transported to the area of operations by heavy lift semi-submersible ships (Figure 2-2) or towed by ocean going tugs. The DPUs can also be pushed by an integrated tug/barge. Successful transportation of such large structures has been proven by commercial heavy lift float-on float-off shipping. The DPUs will float to assist the transportability and the onsite assembly but the Deployable Waterfront may float or be jacked-up to perform the mission. The DPUs can also be bottom seated. Detailed planning and specialized training will be required by the military planners. Once on-site, the DPUs will be joined in the configuration required to serve the particular mission. Individual sections may be outfitted and delivered with modular warehouse facilities, pads or rails for cranes, or connections for utilities permanently affixed. This modular approach will permit rapid deployment, assembly, and multiple uses. Typically four DPUs will be joined to form a 1,200' pier. Tugs will be required to maneuver the DPUs into position for assembly. A specially outfitted work barge may be required to assist. Limited throughput could be established in 7 days, working up to full capability in 14 days as the facility is incrementally installed.

The DWF, installed in an unsheltered area and outfitted with suitable ship mooring and fendering equipment, must be able to support operations in seas up to SS 4 on the Pearson-Moskowitz scale (7.5' significant wave height). The method of mooring the DWF has not yet been determined. One possibility is for the DWF to be restrained by piles (Figure 2-3). The DPUs would not be rigidly connected to the piles. Open chambers in the lower deck would allow the DWF to rise and fall with the tides while the

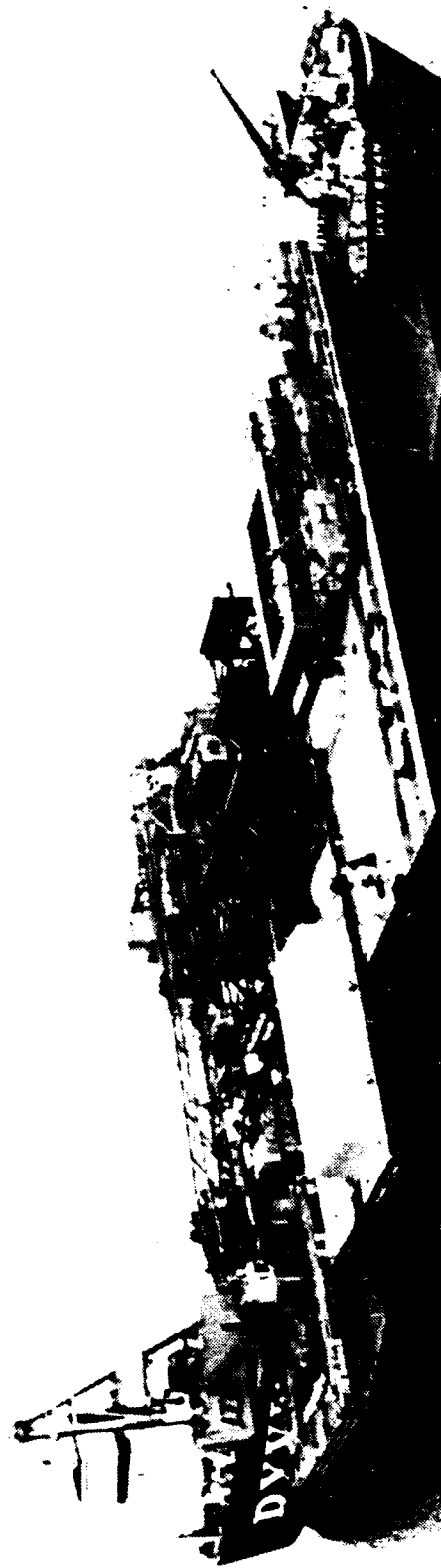
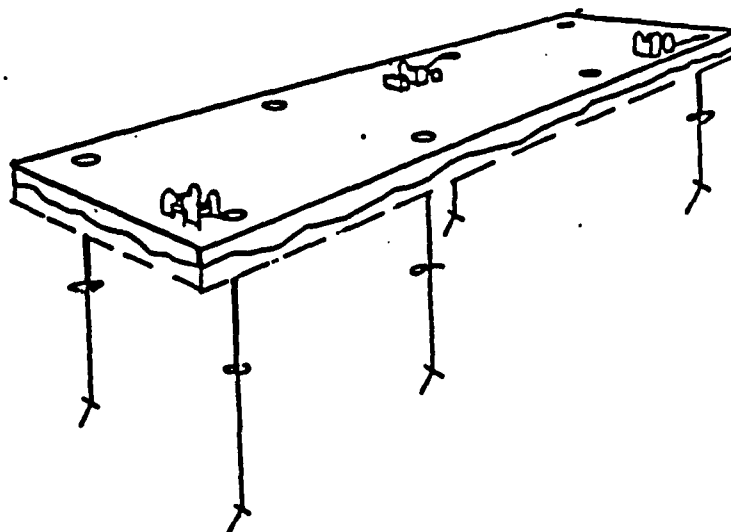
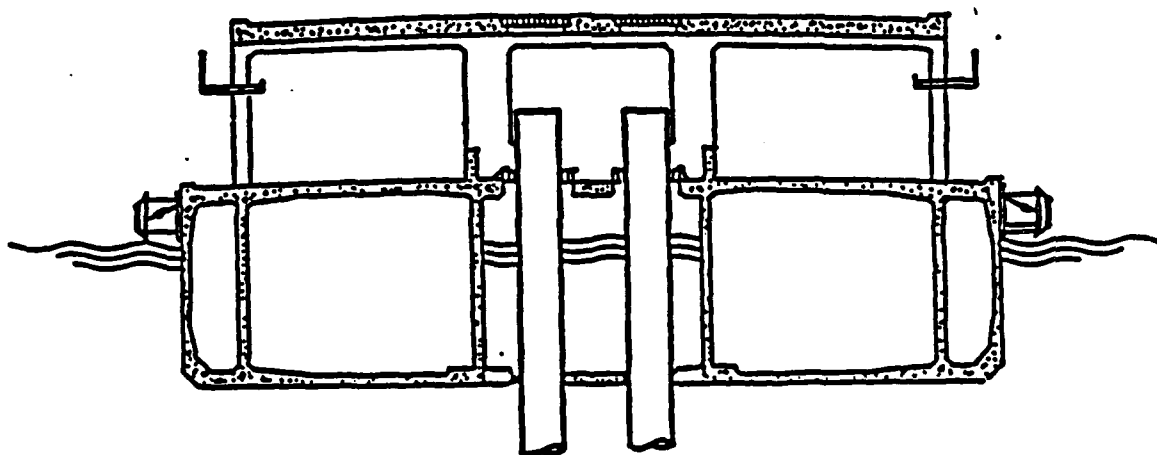


Figure 2-2. Transportation of Flexiport modules (Ref 2).



Tension Anchor Mooring



Cross Section of Pile Restrained Floating Module

Figure 2-3. Mooring Systems. (Reference 2)

piles restrict lateral movement. Replaceable bearing surfaces within these chambers would absorb horizontal loads and protect the DPU from wear and abrasion. A tension anchor mooring system is also being considered (Figure 2-3). This method would use chain or wire rope mooring lines anchored in the sea floor to restrain the DPUs. Tensioning devices on the DPUs would control line tension and accommodate tidal motions. Reference 4 contains a detailed technical comparison of these two methods. A more conventional method would be to jack-up the DWF modules on hollow steel piles. Another potential method is to use a combination of dolphins and mooring barges to take up the ship mooring loads. In all methods, the objective is the same, for the DWF to be held in place to permit operations in SS 4. Lack of ability to sustain cargo throughput beyond SS 2 is one of the greatest shortcomings of current, lighterage and logistics delivery systems.

2.1.2 MISSION DESCRIPTIONS

The DWF is a versatile system which can provide facilities to support a host of mission scenarios. Four missions will be used for this particular comparison. They are:

Mission 1: Port Expansion for LOTS and Fixed Port Operations

Mission 2: Prepositioned Materiel Site Support

Mission 3: Advanced Logistic Support Base

Mission 4: Naval Ship Berthing

The following mission descriptions highlight the services that can be provided by the DWF:

Mission 1: Port Expansion for LOTS and Fixed Port Operations

The main objective of this mission is for the DWF to sustain cargo throughput capability at any location worldwide. This can be accomplished at an unimproved beach LOTS site, eliminating double handling of cargo (ship to lighter, lighter to shore) and freeing lighterage and other discharge systems for redeployment. The DWF can also be utilized at a fixed port when the existing facilities are either inadequate or have been severely damaged. The unimproved beach LOTS mission, being the more demanding, will be the focus of this comparison.

Mission 2: Prepositioned Materiel Site Support

The objective of this mission is to put into place a deep water port to support a prepositioned materiel storage site. A prepositioned materiel site consists of a shore side warehouse and storage area (stocked with ordnance, vehicles, parts, rations, etc.) which has been located in a strategic, friendly nation during peacetime. The warehouse and supplies would be recycled/maintained as necessary but not be distributed until they are needed by the Fleet. The DWF can be used for initial site loadout and again for backloading of the needed supplies upon mobilization. In the interim, the DWF could be used by the host nation for normal port operations in exchange for the use of the site.

Mission 3: Advanced Logistic Support Base (ALSB)

The objective of the DWF in this mission is to provide a mobile ALSB to provide services to the Mobile Logistic Support Force (MLSF). The MLSF will provide supplies and other logistic support to military forces operating abroad. The DWF would provide a facility for shuttle ship cargo transfer (commercial to military), cargo consolidation, and a staging area (containers to

pallets). The DWF could also serve as an auxiliary port for hazardous cargo discharge.

Mission 4: Naval Ship Berthing (Homeport Pier)

The concept of this DWF mission is to provide Naval ship berthing facilities to the Fleet, worldwide. This facility would provide the full range of services that a ship normally receives in its homeport. The DWF could be used to augment damaged or inadequate facilities by increasing the number of available berths. The DWF would be required to support a full range of vessels in CONUS or in a forward area. This capability would be a strategic asset in wartime or when a battle group is deployed for extended periods in distant and unfriendly waters. Services such as maintenance, repair, power generation, water desalination, heliport, and troop support would be provided close to the operating area. In this way the long voyage to the ship's homeport is saved and the ships can maintain station for extended periods.

2.2 EXISTING SYSTEMS

There are already in existence, several structures, systems, and equipment which, if already in the proper tactical position, can meet the mission requirements of three of the four missions. The LOTS mission now performed by the S-T-S LOTS system has a limited SS capability. All of the systems are fully developed and have been widely utilized. Each also has its shortcomings when compared with the DWF. The descriptions which follow will outline the capabilities of each of these systems. Two of these systems, the fixed pier, and the S-T-S LOTS system will later be compared to the DWF in cost, RM&A, and ILS requirements.

2.2.1 THE DeLONG PIER

The DeLong Pier is a reuseable pier facility used extensively by U.S. forces during the Vietnam War to provide deep water berths and other port facilities in sheltered waters. Between 1965 and 1966 29 deep water berths were constructed with the DeLong at a cost of approximately \$100M (in 1966 dollars, not including dredging and shore side construction). The DeLong A (80'x300') cost \$1.1M and the DeLong B (60'x150') cost \$0.6M.

The DeLong Pier is constructed of DeLong barge units. Each barge unit consists of a steel barge supported by several 6 foot diameter, 1.5 inch wall thickness steel piles. To install, the DeLong barge units are towed into position, the piles are lowered and then the barge is jacked up on the piles. For temporary or light duty, the pier can be supported by the pile grippers and held in place with air pressure and without driving the piles. For operation with ships, the piles are driven to refusal then welded to the barge to provide a stronger pier structure. They are intended for use in sheltered areas only. Their ability to withstand wind, current, and ship berthing loads is minimal. To minimize these effects, the pier is usually aligned parallel to the predominant wind and current direction. At the end of the war, all of the DeLong Piers were recovered. The value to the military in terms of availability is much greater than the monetary value of these recovered units.

2.2.2 S-T-S LOTS SYSTEM

The current LOTS capability is dependent on a multitude of interrelated systems. Their operations are complex and interdependent. Joint Logistics Over the Shore (JLOTS) II tests conducted in 1983 and 1984 tested these systems under actual conditions. The results of the test were mixed and point to the need for improvement of the capabilities of certain systems. The

following is a partial list of the major equipment used during JLOTS II and their function:

Causeway Ferry - modular barge-like ferry used to carry vehicles and cargo from ship to shore. It is made up of a powered causeway sections (CSP), pushing one or more unpowered causeway sections (CSNP).

Roll-On/Roll-Off Discharge Facility - The major component is a platform consisting of six CSNPs capable of providing the interface between a Ro/Ro ship and a causeway ferry (or other lighterage) , for the ship to shore transfer of vehicular cargo.

Side Loadable Warping Tug (SLWT) - powered causeway section equipped with an A-frame and deck winch, functioning as a work boat.

Elevated Causeway - CSNPs joined side-to-side to form a pier head for crane operations and end-to-end to form the roadway to shore for vehicle traffic. This transportable pier is elevated above the surf zone on driven piles.

Landing Craft Utility (LCU) - 360,000 pound payload capacity, multi-use landing craft.

Lighter Air Cushion Vehicle - 30 Ton (LACV-30) - Army's high speed air cushion landing craft.

Lighter Amphibious Resupply Cargo - 60 Ton (LARC-60)- Army's heavy lift amphibious lighter.

Landing Craft Mechanized LCM-8 - 120,000 pound payload capacity landing craft.

Auxiliary Crane Ship (T-ACS) - Self deployable cargo ship with three independent twin boom pedestal cranes mounted on deck to handle container and oversize cargo.

Temporary Container Discharge Facility (TCDF) - Army's 250 ton crane mounted on a B-Delong barge.

The current LOTS S-T-S systems and equipment can move cargo and vehicles from ship to shore. However, the following shortcomings were noted:

They are manpower intensive - numerous personnel are required to operate and maintain the many lighters, landing craft, causeway ferries, and other equipment.

They are equipment intensive - numerous pieces of mechanical equipment are required to support LOTS operations. They are dependent upon each other for the entire system to be effective.

They are sea state limited - JLOTS II test results confirm that a SS 3 capability does not exist.

They have little use in peacetime - peacetime utility can be a significant cost offsetting factor.

They are inefficient due to multi-handling of cargo-moving cargo from ship, to lighter, to shore, requires more time, energy, and manpower than moving cargo from ship to shore across a pier.

These are serious shortcomings in the current LOTS capability. A significant improvement in any of these areas will result in improved readiness and effectiveness of the Fleet in power projection.

2.2.3 STANDARD PIER CONSTRUCTION

The standard pile supported fixed pier now provides the Fleet support services which are planned for the DWF. The fixed pier provides a proven platform for cargo transfer, Naval ship berthing, and for the delivery of logistic support to the Fleet in CONUS and abroad.

Construction of standard pier and port facilities is expensive and time consuming. The approximate construction cost (not including site preparation or dredging cost) of building an 80'x1200' pier is \$20.3M. This cost can vary significantly, depending on the location and the ambient environmental conditions. The cost of warehouse space, maintenance facilities, housing and material handling equipment is additional. The time required to build such a pier is approximately one to two years, again, depending on the ambient environmental conditions.

Standard pier construction is not a viable substitute for the DWF. It takes many months from the order to build until the facility is operational, and it is not transportable. It is not cost effective to build standard piers in locations where the political climate may vary thus requiring renegotiations to maintain the facility.

There are pier building techniques that can be used to speed up construction. For example, under wartime conditions in Vietnam, two 90'x600' piers were constructed in about 6-1/2 months using the "Reeves" jacket piling prefabrication method. The prefabricated pier components were barged to DaNang, Vietnam for the on-site construction. Both piers were constructed and put into service after 2 months of on-site work (Reference 5).

2.3 BASELINE COMPARISON SYSTEM

The baseline comparison system (BCS) for the DWF will describe and quantify those characteristics of the system which are necessary to make a realistic comparison between it, the fixed pier, and the S-T-S LOTS system. The BCS for the DWF will consist of four DPUs joined lengthwise to provide 1200' of ship berthing space. In addition to the basic facility, considerable support equipment is required. This support equipment is common to all four missions, except as noted.

BCS COMMON SUPPORT EQUIPMENT

Shore-side connections, roadway, pier utilities, etc.

Ro/Ro ships ramp interface.

4 mobile container handling cranes

Mooring System, Fendering System

Administration Office , cargo inventory system,
communication equipment, utilities

8 forklift trucks

8 container handlers

20 flatbed trucks or tractor trailers

Mission 1 Unique Support Equipment - Mooring and fendering system capable of sustaining SS 4 ship loads and wave forces. Extended roadway to shore.

Mission 2 - No unique support equipment

Mission 3 Unique Support Equipment - 250,000 square feet of additional storage and warehouse space. Additional MHE to service the storage and warehouse areas.

Mission 4 Unique Support Equipment - Utilities (steam, fresh water, power, telephone, compressed air, sewage service) and ship repair facilities.

2.4 SUPPORTABILITY, COST AND READINESS DRIVERS

The factors affecting the supportability, cost, and readiness of the DWF will determine its suitability for service. These three parameters are useful in measuring the practicality of developmental systems. Table 2-1 summarizes the impact of these factors on the supportability, cost, and readiness of the DWF. Tradeoffs among these factors must be made during the preliminary design process in order to optimize the DWF for the mission objectives. The following six major supportability, cost, and readiness drivers have been identified:

Size - The choice of the size of the DPU will be determined by such factors as the material of construction, method of transport, and the design of the unit. A nominal 1200' pier is required for each scenario. Six 200' sections will likely cost more than three 400' sections however. The smaller units will be easier to transport, permit greater configurational flexibility, but increase the on site assembly time. The larger units, however, would provide a more stable platform. 300 foot DPUs are used in this report as a compromise between these factors, and will enable use of a larger number of available transportability assets.

Table 2-1
RELATIVE IMPACT OF THE
SUPPORTABILITY, COST, AND READINESS DRIVERS

FACTOR:	SUPPORTABILITY	COST	READINESS
DPU Size	N	H	L
Material of Construction	H	L	L
Environmental Capability	H	H	H
Procurement/ Ownership Option	N	H	L
Method of Transportation	N	H	L
Configuration	N	L	H

Negligible - N

Low - L

High - H

Material - The material and location of construction will affect the cost, supportability, and readiness of

the DWF. The material of construction will be reinforced concrete or steel. The cost of the steel unit will initially be lower, but steel's maintenance costs will be higher. The concrete unit will have less maintenance and a longer useful life. The steel unit will require periodic dry docking to replenish the surface protection. Thus the supportability and readiness are affected as well.

Environmental Capability - A system designed with SS 4 capability will certainly cost more than one designed for sheltered environments. Such a system will also exhibit a greater throughput capability and availability than one designed for calmer water. The support requirements of a SS 4 capable system will be greater, because the additional mooring systems will require more maintenance and periodic inspection.

Procurement/Ownership - The cost to the Government to own and operate the DWF can be reduced significantly if these costs are shared with commercial interests. This would require a DWF design that can satisfy the needs of commercial interests as well as fulfill the peace and wartime military requirements. If used by a commercial interest however, rapid turnover to military authority must be assured (affecting readiness). The following four procurement/ownership options are available:

- Industry financed and built for commercial use with an arrangement for contingency use by the military
- Industry financed and built and chartered to

the military (with possible peacetime utilization by commercial interests)

- Military financed and industry built for commercial use, with an arrangement for contingency use by the military
- All military financed, built, owned, and operated.

Transport Method - The DWF will be either carried by heavy-lift ship or barge, or towed by ocean going tug. The number of heavy-lift ships in the world is very limited. The availability of one or more for charter or purchase by the military is unknown. There are several ocean going tugs in the Navy's Fleet and many in the commercial sector available for charter. The operational costs and readiness of the DWF will be affected by this decision.

Configuration - The decision as to whether the DWF will be designed as a single or double deck pier has not been made. This factor ties in closely with size. A single deck pier will necessarily be wider than a comparable double deck pier. A double deck pier is more productive and flexible. The difference in height and width will impact the transportability of the DWF which in turn will impact O&S costs.

2.5 RELIABILITY, MAINTAINABILITY AND AVAILABILITY COMPARISON

The RM&A characteristics of the DWF must meet certain minimum requirements in order for it to be considered suitable for military service. Because of the type of system that it is,

the DWF will inherently have good RM&A characteristics. It is however, subject to rather severe environmental conditions. As such, it is likely that the external forces acting upon it will greatly influence its RM&A values. Because the severity of the environment is a function of the geographic location and the season, care must be taken to ensure that any RM&A comparison takes this into account.

The RM&A of a pier is difficult to measure quantitatively. This is because the common measures of RM&A cannot easily be applied to a single unit entity such as a building, a parking lot, or a pier. Surely the RM&A characteristics of the supporting trucks, cranes, and other machinery are easily quantifiable. Much of this machinery is required for the DWF and the fixed pier in equal quantities so that their contribution (or penalty) to each in terms of RM&A is approximately equal and therefore cancels out. The throughput test during JLOTS II demonstrated the operational and sea keeping limitations of the various landing craft and powered ferries of the S-T-S LOTS system. The maintenance requirements of this S-T-S equipment are extremely high. Almost intuitively one can say that the RM&A characteristics of the S-T-S LOTS equipment are less favorable than those of a fixed pier or the DWF.

2.5.1 RELIABILITY

Reliability is defined as the probability that a system will perform its intended function, failure free, for a specified period of time, and under stated conditions. Its most common measure is mean time between failure (MTBF), expressed in hours.

In Mission 1, the reliability of the DWF is expected to be higher than the S-T-S LOTS equipment. This is because of the inherent unreliability resulting from the dependence on such a large number of mechanical equipments in the S-T-S LOTS system. The redundancy of the S-T-S LOTS equipment may offset the

unreliability of individual equipment items. In other words, the S-T-S LOTS system can continue to function (at a reduced throughput capacity) even if several individual components have failed. The DWF on the other hand will not suffer many major failures. Minor failures such as damage to the pavement or the loosening of a pile will not totally incapacitate the facility. If one DPU is damaged, it can be uncoupled so that operations can continue on the other three. The double deck configuration will also contribute to DWF reliability.

In Missions 2 through 4, the fixed pier is expected to be more reliable than the DWF. This is because fixed pier failures resulting from normal use will be less frequent and probably less severe. (Only a catastrophic failure of a fixed pier will take it completely out of service.) In addition to this, there is a large body of knowledge in the Navy concerning all aspects of fixed pier design, construction, and operation. This disparity in design and operational experience will contribute to an increase in the reliability of a fixed pier.

Listing in order of decreasing reliability, first would be the fixed pier, then the DWF, followed by the S-T-S LOTS System.

2.5.2 MAINTAINABILITY

Maintainability is a measure of a system's ability to be retained in a ready and operable condition when maintenance is performed in accordance with prescribed procedures and resources. Its most common and useful measure is mean time to repair (MTTR), expressed in hours.

The MTTR of the DWF is expected to be low compared to the fixed pier. This is because repairs to a fixed pier will often take a long time to accomplish as they may require structural work, pile repair, or extensive concrete work. The DWF will be easier to repair because of the greater access to utility

equipment and structural components. During the DWF design process, emphasis will be placed on incorporating features that facilitate ease of repair. All tools and materials needed to repair the most commonly anticipated failures will be ready and available. Preventive maintenance requirements are minimal. All corrective maintenance will be performed by on site personnel.

Preventive maintenance requirements of the S-T-S LOTS equipment is very high. It includes much cleaning, lubrication, and adjustment. That, coupled with the difficulty of performing these and other tasks on the beach or in the mother ship will contribute to a poor maintainability. The difficulty of supplying the multitude of parts, tools, and materials required of the S-T-S equipment when and where required will also adversely affect its maintainability. Thus for Mission 1, the DWF is expected to exhibit maintainability slightly better than the S-T-S LOTS system of equipment.

Listing these systems in order of decreasing maintainability (increasing MTTR) one would list the DWF first followed very closely by the fixed pier. Though the individual repair times for the DWF and fixed pier will be long, the overall repair times for the S-T-S LOTS 'system' will be even greater. The S-T-S LOTS equipment would be last.

2.5.3 AVAILABILITY

The availability of a system is often used as a measure of readiness. It is a measure of the degree to which an item is in an operable and committable state at the start of a mission, when the mission is called for at a random point in time. It is commonly expressed as operational availability (Ao) expressed in percent.

The availability of the DWF in Mission 1 is expected to be high compared to the S-T-S LOTS equipment. This is simply because of the increased seaworthiness of the DWF. Many lighters and cargo discharge systems are inoperable (or suffer significantly reduced productivity and safety) beyond SS 2. The DWF, however, will be designed to be able to sustain operations in SS 4. Downtime of the DWF due to maintenance and repair is expected to be minimal. Some of the S-T-S LOTS equipment on the other hand is expected to be down for repairs or maintenance much more frequently. The S-T-S LOTS system, however, has a built-in redundancy because of the large number of each type of equipment (see Section 2.7.3). Unless a large percentage experience outages for maintenance or repair, the system will be able to continue operating. None-the-less, the availability of the DWF in this scenario is expected to be greater than the S-T-S LOTS equipment.

In Missions 2 through 4, the availability of the fixed pier is expected to be equal to that of the DWF. The availability of a fixed pier in these missions is close to 100%. The reason for this is that in a sheltered environment, as these three missions are, there are few conditions that would force a pier to cease operations. The only ones that come to mind are major repairs for severe damage or a severe storm. Any of these would affect the fixed pier and the DWF equally. Thus one would conclude that for these missions, the DWF and fixed piers have equally high availability.

2.6 LOGISTIC SUPPORT RESOURCE REQUIREMENTS COMPARISON

The logistic supportability of a candidate developmental system is an important determinant in the assessment of its suitability for military service. This is borne out by the fact that many otherwise sound designs for new equipment are rejected because of the unjustifiable burden that they would place on the

Navy's support structure. Logistic support resource requirements also have a profound impact on the life cycle cost of a system.

A comparative analysis of the logistic requirements of several systems requires that each of the systems be evaluated in the following nine support areas:

Maintenance

Manpower and Personnel

Supply Support

Support and Test Equipment

Training and Training Devices

Technical Documentation

Computer Resources

Packaging, Handling, Storage, and Transportation

Facilities

These logistic elements, described in Sections 2.6.1 through 2.6.9 of this report, will need to be broken down further as the project progresses and more detailed information is available. The logistic support requirements of the three systems will be evaluated in the context of the missions described in Section 2.1.2 and the duty cycles.

2.6.1 MAINTENANCE

The maintenance requirements of the LOTS DWF will be considerably less than its counterpart, the S-T-S LOTS discharge system, principally because of the elimination of the lighterage. From Reference 6, the maintenance requirements of a fixed pier are about 1/3 higher than those of a floating transportable pier. This comparison is directly analogous to the prepositioned deployable waterfront compared to the prepositioned fixed pier. The DWF ALSB mission will also have slightly lower requirements than the fixed pier. The homeport mission maintenance requirements will be lower than the fixed pier because of the additional floating assets for ship services, utilities, and the limited repair capability.

DWF maintenance will cover the mooring system and the DPUs. Regular and thorough periodic inspections will be needed to verify their structural integrity. The frequency and depth of the inspections will depend on the local environmental conditions and the final design features of the DWF (concrete vs. steel construction, pile vs. tension anchor mooring, deck, etc.)

Preventive maintenance will consist of surface coating, lubrication, and replacement of fenders and other wearing parts. Corrective maintenance will consist of surface and structural repairs to the beach interface, mooring system, piers, etc. It is anticipated that all maintenance and repair will be performed by DWF maintenance crews on site, with assistance from outside when special skills (divers, concrete/steel inspectors) or equipment are required.

2.6.2 MANPOWER AND PERSONNEL

The peacetime manpower and personnel requirements of the DWF will be the same as the fixed pier for like operations.

Personnel for operations and maintenance of the S-T-S LOTS would be higher than the DWF, because of the large amount of MHE and lighters. The operations of ship berthing, loading and unloading cargo, and performance of routine maintenance and repair will likely require more manpower than the same activities performed on a fixed pier located in a sheltered area. Table 2-2 summarizes the estimated operation and maintenance personnel requirements of the three systems.

Table 2-2. Personnel Requirements Summary
(Number of Personnel)

		DWF		S-T-S LOTS		Fixed Pier	
		Opn.	Maint.	Opn.	Maint.	Opn.	Maint.
Mission 1 LOTS	Peace	100	100	672	386	N/A	N/A
	War	400	500	896	1660	N/A	N/A
Mission 2 Preposition	Peace	100	50	N/A	N/A	100	50
	War	400	400	N/A	N/A	400	200
Mission 3 ALSB	Peace	100	100	N/A	N/A	100	100
	War	400	400	N/A	N/A	400	400
Mission 4 Homeport	Peace	40	20	N/A	N/A	40	20
	War	160	160	N/A	N/A	160	160

Opn. = Operation

Maint. = Maintenance

2.6.3 SUPPLY SUPPORT

The supply support requirements of the DWF are not significantly different from those of a conventional fixed pier in missions 2 through 4. The only unique DWF supplies or support equipment would be required for the LOTS mission because of the ship offloading operations in SS 4. The supply support requirements of the S-T-S LOTS system are quite high because of the quantity and variety of mechanical equipment. The general requirements of the DWF are as follows:

<u>ITEM</u>	<u>USAGE</u>
P.O.L.	Support Equipment, Utilities
Spare, Repair Parts	Support Equipment
Food, Troop Support	DWF
Fenders, DWF Consumables	DWF
Ship Spare and Repair Parts	Ships Using DWF

The DWF will arrive in the operational area with an initial load of all required supplies. From that point on, replenishment stocks will be supplied regularly by supply ships. Most of the supplies required are used elsewhere in the Navy and are therefore already in the supply system. DWF unique supplies will be added to the allowance parts list (APL) when identified. These DWF unique parts and supplies will likely be provided as kits, e.g. fender repair kit, surface repair kit, etc.

2.6.4 SUPPORT AND TEST EQUIPMENT

As with a standard fixed pier, the DWF requires a substantial amount of support equipment to perform as designed. The support equipment listed in the BCS (Section 2.3 of this report) represents the most up to date estimate of support equipment requirements. This BCS is sufficient to provide the capabilities outlined in the draft tentative operational requirements (TOR) for the DWF.

The support and test equipment that is required for a fixed pier in missions 2 through 4 is very similar to that of the DWF. The DWF's will be slightly higher because of the mooring system and related equipment. The support and test equipment required of the S-T-S LOTS equipment will be significantly higher. This, again, because of the quantity and diversity of mechanical equipment.

2.6.5 TRAINING AND TRAINING DEVICES

Training for DWF support and operation will have to cover several distinct functions. The new training functions are associated with the initial setting up of the DWF. Once the facility is operational, most of the tasks performed will be similar to any port, warehouse, or berthing pier.

DWF TRAINING

Loading and unloading of DPUs on semi-submersible ships

Rigging the DWF for towing

DWF on-site assembly (pile restrained or tension anchored)

Ship mooring to the DWF

Cargo operations in SS 4

Training for these unique DWF functions will consist of classroom training and practice with the actual hardware. This will require a school to be established at a site close to where the DWF is stationed. The on-site operational personnel and equipment (heavy lift ship, tugs, MHE, etc.) will be used to augment classroom instruction. Training devices will consist of operation manuals and video tapes.

Cargo transfer operations on the sheltered DWF will not be significantly different than on a normal fixed pier. No unique training or training devices will be required. This is also true of most DWF maintenance. This general training will likely take place at one of the established fleet training centers. MHE on the LOTS DWF will require additional training in the use of motion compensation equipment.

2.6.6 TECHNICAL DOCUMENTATION

Technical documentation requirements of the DWF are similar to fixed pier operations. Additional technical documentation will consist of manuals for the installation, operation and maintenance of the DWF. Most of the required documentation for the supporting systems already exists. The following major documents are required for the development program:

TECHNICAL DOCUMENTATION

Operating Instructions

Technical Manuals

Planned Maintenance System (PMS)

ACQUISITION DOCUMENTATION

Operational Requirement

Integrated Logistic Support Plan

Test and Evaluation Master Plan

Navy Training Plan

System Safety Program Plan

Environmental Impact Assessment

Human Engineering Program Plan

Logistic Support Analysis

Reliability and Maintainability Program Plans

2.6.7 COMPUTER RESOURCES

Very minimal computer resources are required to support the DWF. They will be similar to those required for similar missions performed with fixed piers. As listed previously under Support and Test Equipment, personal computers (PC) for cargo transfer logging and pier management will be required. Off the shelf software packages are readily available to support these tasks.

The preposition and ALSB DWFs will require additional computer resources to track cargo movement, location, and identification for storage and reshipment. The scheduling of ship repair resources, men, material, time, and costs, will be an additional home port mission requirement.

2.6.8 PACKAGING, HANDLING, STORAGE, AND TRANSPORTATION

Each sub-element will be addressed individually for each comparative system. Packaging, handling, storage and transportation is not applicable for the fixed pier installations.

PACKAGING

The DWF packaging requirements are analogous to preparation for delivery and use. Preparing the DWF for transportation will consist of the installation of various components to permit safe and stable delivery to the objective area. These may consist of pad eyes, tie-downs, shackles, and other load bearing and wire rope fittings. These fittings will be used to lash the DWF securely to the heavy lift ship, barge or tug during delivery. Similar requirements exist for the shipment of S-T-S LOTS equipment.

HANDLING

Special handling procedures will have to be developed for DWF transportation. Specific methods, tailored to the DWF's construction, strength, and rigidity will ensure that it is handled so as not to sustain or inflict any damage during transportation. These handling procedures will pertain to rigging, lifting, lashing, towing, unloading, and any other transportation related operations.

STORAGE

In peacetime, the Mission 1 DWF could be used as a commercial pier or Navy pier. There may also be instances when the DWF, is to be stored for extended periods of time. There are several ways to accomplish this. The support equipment will be

stored ashore in a covered area in order to minimize deterioration and corrosion. One option is for the DWF to be stored in freshwater in rivers. Many ships in the reserve fleet are currently stored this way. The preposition, ALSB and Homeport DWFs would always be in use. S-T-S LOTS equipment in Mission 1 will be stored in dry open locations, with selected elements in covered storage when not in use.

TRANSPORTATION

Transportation will have to be provided for the DWF. Transporting the DWF to the objective area intact and at a reasonable cost and in a reasonable amount of time will take careful planning. As discussed previously, there are three methods under consideration for transporting the DWF. The first calls for the DWF to be carried to the objective area by a heavy lift semi-submersible ship. This is the fastest method (max speed 16 kts.). One advantage of this approach is that two to three DPUs and a considerable amount of support equipment can be delivered in one shot. Once in the objective area however, tugs (which can also be carried), will be required to help position and assemble the DWF and remain on hand to assist the ships on and off the facility.

The second option calls for the DWF to be towed on heavy-lift, semi-submersible barges (widely used in the oil industry to transport oversized loads) by ocean going tugs. The maximum speed in this option is approximately six knots. An advantage of this option is that once in the objective area, the same tug can assist in the assembly of the DWF. The very slow speed is a disadvantage from the standpoint of exposure. Transportation by integrated tug/barge is also feasible, with a maximum speed of about 10 knots.

The final option calls for the DWF to be towed by itself to the objective area. A low water plane area bottom design can be incorporated into the DWF to increase the normal speed of between four and six knots. A trade-off must be made between the value of increased speed vs. the added cost of construction of the low waterplane hull form.

In all probability, more than one of these methods will be employed. For a particular mission, the factors that will determine the preferred method are:

- Size and weight of final DPU design
- Distance to the objective area
- Anticipated sea states on the way to the objective area
- Urgency of the need in the objective area
- Availability of resources (heavy lift float-on/off ships, barges, tugs)
- Availability of tugs in the objective area for assistance in DWF assembly.

The transportability of the S-T-S LOTS system requires the availability of commercial shipping suitably configured with the heavy lift capabilities required. The LASH and SEABEE ships have been utilized in testing and the necessary ancillary gear has been developed.

2.6.9 FACILITIES

No facilities will be required for the support of the DWF if

peacetime uses are found. If not, then the support will be limited to storage facilities and shore-side repair/maintenance warehouse facilities (covered storage and fenced open areas). Storage facilities (if covered storage ashore is required) will consist of low warehouse type structures. An inexpensive prefabricated off-the-shelf system will likely be used. When required, office and living spaces can be made up from converted trailers or 40' containers. Shop, warehouse, and machinery space can be rapidly constructed from prefabricated modular systems.

Extensive facility requirements exist for supporting the S-T-S LOTS since there is no peacetime use of the equipment.

2.7 OPERATION AND SUPPORT COSTS

Operation and support (O&S) costs entail all of the expenses attributable to the utilization of the DWF system. These include all of the personnel, material, and consumable costs incurred in operating the DWF over its anticipated 25 year life. O&S costs will comprise the largest portion of the life cycle cost (LCC). The analogy method, based on guidance from MIL-HDBK-259 Life Cycle Cost in Navy Acquisition, will be used to estimate and project the O&S costs of the DWF. This technique bases its estimate on observation of similar equipment for which hard data is available. This data will be modified to reflect differences in physical and operational characteristics.

The major cost elements used from MIL-HDBK-259 and Reference 1 are as follows:

Operation and Support Costs

- a. Personnel
- b. Replacement Training

- c. Personnel Replacement
- d. Indirect Personnel
- e. Consumables
- f. Direct Maintenance
- g. Modifications
- h. Support Equipment Replacement

The O&S costs are determined for 25 years of life with the duty cycle of the assumed the scenarios. These figures will be used in comparing alternative systems. All costs are in 1987 dollars.

For the analysis, a scenario was developed for the DWF in each of the four missions. Each scenario specifies certain equipment, personnel, and operating cycles. For each of four missions, DWF costs are compared to the costs of a comparable existing system. The systems chosen for comparison in each case are based on comparable capabilities of throughput and ship service.

For Mission 1 (Port Expansion for LOTS), a 1200' sea state 4 capable DWF is compared to the S-T-S LOTS system.

For Mission 2 (Prepositioned Materiel Site Support), a 1200' prepositioned DWF is compared to a fixed prepositioned pier.

For Mission 3 (Advanced Logistic Support Base), a 1200' DWF with storage and warehousing space is compared to a fixed pier with storage and warehousing.

For Mission 4 (Naval Ship Berthing), a 1200' DWF with utilities and repair facilities is compared to a fixed pier with utilities and repair facilities.

Sections 2.7.2 through 2.7.4 list the specific data for each mission scenario. The manning levels for each system and mission were listed in Table 2-2.

2.7.1 O & S COST CALCULATION METHOD

The following cost method and factors used are from Reference 1.

Hardware Manufacture - The actual cost of the hardware is used where noted with the remaining hardware costs estimated based on experience and judgement. This hardware cost is also used with the assigned factors in the calculation of other indirect investment costs and with the maintenance, modifications and support costs for the O & S costs.

Operation and Support - These are the estimated costs to operate, maintain and support the system.

- a. Personnel - This is the cost of personnel pay and allowances for operation and maintenance of the system. Personnel costs are based on the manning level for the particular mission scenario and the following hourly wages:

\$8.00/hr peacetime operation

\$12.00/hr wartime operation

\$15.00/hr storage (civilian maintenance)

- b. Replacement Training - This is the annual cost of training rotating troops.

It is estimated as $(0.299) \times$ peacetime (operation and training cost).

- c. Personnel Replacement - This is the sum of administrative and other costs to replace rotating military personnel.

It is estimated as $(\$0.299) \times$ (peacetime operation and training man years).

- d. Indirect Personnel - This is the cost of food, shelter, and other such personnel support costs. It is estimated as $(\$269.00) \times$ (peacetime operation and training man years).

- e. Consumables - This is the cost of fuel, oil, replacement spares, and maintenance materials required to keep the system operational.

It is estimated with the data from the previously described mission scenarios and the following:

Maintenance Material = $(0.005) \times$ (manufacturing hardware cost)

Replacement Spares = $(0.005) \times$ (manufacturing hardware cost)

PETROLEUM, OIL, AND LUBRICANTS

Boats:

Fuel = (number of engines) x (operating hours) x (23.9 gal/hr) (\$1.00/gal).

Oil = (number of engines) x (operating hours/100) x (5.75 gal/change) x (\$4.00/gal).

Compressors/generators:

Fuel = (number of engines) x (operating hours) x (1.45 gal/hr) (\$1.00/gal).

Oil = (number of engines) x (operating hours/250) x (2 gal/change) (\$4.00/gal).

Cranes:

Fuel = (number of engines) x (operating hours) x (7.5 gal/hr) (\$1.00/gal).

Oil = (number of engines) x (operating hours/250) x (7 gal/change) x (\$4.00/gal).

Rough Terrain Forklifts:

Fuel = (number of engines) x (operating hours) x (6 gal/hr) (\$1.00/gal).

Oil = (number of engines) x (operating hours/250) x (2 gal/change) x (\$4.00/gal).

Trucks:

Fuel = (number of engines) x (operating hours) x (4 gal/hr)
(\$1.00/gal).

Oil = (number of engines) x (operating hours/250) x (2
gal/change) (\$4.00/gal).

- f. Direct Maintenance - This is the cost to perform the repairs and maintenance required to keep the system operational.

It is estimated at (0.005) x hardware manufacturing cost.

- g. Modifications - This is the cost to perform necessary alterations to the system due to new requirements, environment, or mission.

It is estimated at (0.005) x manufacturing hardware cost.

- h. Support Equipment Replacement - This is the annual cost of replacing worn out or damaged support equipment.

It is estimated at (0.005) x hardware manufacturing cost.

2.7.2 DEPLOYABLE WATERFRONT DATA

All Missions

The DWF consists of four 300' DPUs capable of berthing 4 ships.

The hardware manufacturing cost of the basic DWF is \$23.4M (from Reference 6) for all missions. Added to this is the estimated cost of mission unique support equipment but not the cost of the common support equipment described in the BCS.

Mission 1 (LOTS)

Additional hardware manufacturing costs were estimated from the Naval Civil Engineering Laboratory Advanced Cargo Transfer Facility Program information as follows:

Sea state 4 fenders	\$8.0M
Sea state 4 moor barge	\$16.0M
1800 Ft roadway	<u>\$8.0M</u>
TOTAL =	\$32.0M

The consumable costs are estimated using 40 operating engines (trucks, cranes, forklifts, generators, and auxiliary equipment). It is assumed that only half of the DWF would be used for peacetime training purposes and that 100 men would divide their time between operations and maintenance. The man hour costs are estimated from reference 1. The number of men is estimated to be 50 men per ship for two ships in peacetime and 100 men per ship for 4 ships in wartime.

Duty Cycle							
Function	Units	Months	Day/month	Men	MY	Hr/day	\$/Man hr
Peace/Ops	0.5	294	15	100	1225	8	\$8
Peace/maint	0.5	294	15	100	1225	8	\$8
War/Ops	1	6	30	400	200	20	\$12
War/maint	1	6	30	500	250	20	\$12

Mission 2 (Prepositioned)

Additional hardware manufacturing costs: None

The consumable costs are estimated using 40 operating engines (trucks, cranes, forklifts, generators, and auxiliary equipment).

Duty Cycle							
<u>Function</u>	<u>Units</u>	<u>Months</u>	<u>Day/month</u>	<u>Men</u>	<u>MY</u>	<u>Hr/day</u>	<u>\$/Man hr</u>
Peace/Ops	1	15	15	100	125	8	\$8
Peace/maint	1	15	15	50	63	8	\$8
War/Ops	1	6	30	400	200	20	\$12
War/maint	1	6	30	400	200	20	\$12

Mission 3 (ALSB)

Additional hardware manufacturing cost for Warehouse/Storage Facilities is estimated to be \$3.2M. The consumable costs are estimated using 68 operating engines (trucks, cranes, forklifts, generators, and auxiliary equipment).

Duty Cycle							
<u>Function</u>	<u>Units</u>	<u>Months</u>	<u>Day/month</u>	<u>Men</u>	<u>MY</u>	<u>Hr/day</u>	<u>\$/Man hr</u>
Peace/Ops	1	294	15	100	2450	8	\$8
Peace/maint	1	294	15	100	2450	8	\$8
War/Ops	1	6	30	400	200	20	\$12
War/maint	1	6	30	400	200	20	\$12

Mission 4 (Naval Ship Berthing)

Additional hardware manufacturing costs for Utility/Repair Equipment is estimated to be \$7.0M. The consumable costs are based on 48 operating engines (trucks, cranes, forklifts, generators, and auxiliary equipment).

Function	Units	Months	Duty Cycle		Men	MY	Hr/day	\$ /Man hr
			Day/month					
Peace/Ops	1	294	15		40	980	8	\$8
Peace/maint	1	294	15		20	490	8	\$8
War/Ops	1	6	30		160	80	20	\$12
War/maint	1	6	30		160	80	20	\$12

2.7.3 FIXED PIER DATA

Missions (2, 3, 4)

The hardware manufacturing cost of the basic 1200' fixed pier capable of berthing 4 ships is \$20.3M (from reference 6). Added to this is the estimated cost of the mission unique support equipment but not the cost of the common support equipment described in the BCS.

Mission 2 (Prepositioned)

Additional hardware manufacturing costs: None

The consumable costs are based on 40 operating engines (trucks, cranes, forklifts, generators, and auxiliary equipment).

Duty Cycle

<u>Function</u>	<u>Units</u>	<u>Months</u>	<u>Day/month</u>	<u>Men</u>	<u>MY</u>	<u>Hr/day</u>	<u>\$/Man hr</u>
Peace/Ops	1	15	15	100	125	8	\$8
Peace/maint	1	15	15	100	125	8	\$8
War/Ops	1	6	30	200	100	20	\$12
War/maint	1	6	30	200	100	20	\$12

Mission 3 (ALSB)

Additional hardware manufacturing costs for Warehouse is estimated to be \$1.1M. The consumable costs are based on 68 operating engines (trucks, cranes, forklifts, generators, and auxiliary equipment).

Duty Cycle

<u>Function</u>	<u>Units</u>	<u>Months</u>	<u>Day/month</u>	<u>Men</u>	<u>MY</u>	<u>Hr/day</u>	<u>\$/Man hr</u>
Peace/Ops	1	15	15	200	250	8	\$8
Peace/maint	1	15	15	100	125	8	\$8
War/Ops	1	6	30	400	200	20	\$12
War/maint	1	6	30	200	100	20	\$12

Mission 4 (Naval Ship Berthing)

Additional hardware manufacturing cost for Utility/Repair Equipment is estimated to be \$5.0M. The consumable costs are based on 48 operating engines (trucks, cranes, forklifts, generators, and auxiliary equipment).

Duty Cycle

<u>Function</u>	<u>Units</u>	<u>Months</u>	<u>Day/month</u>	<u>Men</u>	<u>MY</u>	<u>Hr/day</u>	<u>\$/Man hr</u>
Peace/Ops	1	294	15	40	980	8	\$8
Peace/maint	1	294	15	20	490	8	\$8
War/Ops	1	6	30	80	40	20	\$12
War/maint	1	6	30	40	20	20	\$12

2.7.4 S-T-S LOTS DATA (MISSION 1)

Operating and Support scenario assumes that the 25 years of life consists of 24.5 years peacetime and 6 months of war. The S-T-S LOTS system consists of the following:

4	Ro/Ro	2	in storage	life 25 years
		2	in use	life 10 years
3	ELCAS	2	in storage	life 25 years
		1	in use	life 10 years
22	SLWT	10	in storage	life 25 years
		12	in use	life 10 years
40	CSP	20	in storage	life 25 years
		20	in use	life 10 years
180	CSNP	90	in storage	life 25 years
		90	in use	life 10 years

Military Personnel hours of operation were calculated for the life cycle in the above scenario based on an hourly wage of \$8.00/hr peacetime, \$12.00/hr wartime and \$15.00/hr storage

maintenance (civilians). The personnel requirements for this system for peacetime and wartime maintenance and operation are presented in Table 2-2.

Hardware manufacturing costs (based on 1987 OPN FYDP) for the above equipment were derived as follows: (replacement of the units in use every 10 years and the units in storage every 25 years.)

4	Ro/Ro	=	\$1.6m each	*	(2 + 2*2.5)	=	11.2
3	ELCAS	=	\$16.0m each	*	(2 + 1*2.5)	=	72.0
22	SLWT	=	\$1.2m each	*	(10 + 12*2.5)	=	48.0
40	CSP	=	\$1.0m each	*	(20 + 20*2.5)	=	70.0
180	CSNP	=	\$0.2m each	*	(90 + 90*2.5)	=	63.0

Total hardware manufacturing cost for the S-T-S LOTS System = \$264.2M.

The consumable costs are based on 143 operating engines (lighterage, SLWTs, trucks, cranes, forklifts, generators, and auxiliary equipment).

2.7.5 COST COMPARISON RESULTS

Table 2-3 summarizes the results of the O&S cost comparison. The hardware manufacturing cost of each of the systems compared is also listed because this is an important factor in the estimation of each system's O&S costs. The hardware manufacturing cost of the S-T-S LOTS system is significantly greater than all of the other systems' because of the extensive list of equipment that is required to accomplish that mission. The initial cost of the DWF LOTS system is higher than the other

TABLE 2-3 Operation and Support Cost Analysis Results

COST ELEMENT	DEPLOYABLE WATERFRONTS				S-T-S				FIXED PIERS			
	1 LOTS	2 PREPOSITION	3 ALSB	4 HOMEPORT	1 LOTS	2 PREPOSITION	3 ALSB	4 HOMEPORT	1 LOTS	2 PREPOSITION	3 ALSB	4 HOMEPORT
Direct Manufacture	\$53,400,000	\$23,400,000	\$26,600,000	\$30,400,000	\$264,200,000	\$20,300,000	\$21,400,000	\$25,300,000	\$264,200,000	\$20,300,000	\$21,400,000	\$25,300,000
Personnel	\$77,184,000	\$23,616,000	\$77,184,000	\$30,873,600	\$275,359,680	\$23,616,000	\$77,184,000	\$30,873,600	\$275,359,680	\$23,616,000	\$77,184,000	\$30,873,600
Replacement Training	\$23,078,016	\$7,061,184	\$23,078,016	\$9,231,206	\$6,823,185	\$7,061,184	\$23,078,016	\$9,231,206	\$6,823,185	\$7,061,184	\$23,078,016	\$9,231,206
Personnel replacement	\$1,465	\$75	\$1,465	\$586	\$7,750	\$75	\$1,465	\$586	\$7,750	\$75	\$1,465	\$586
Indirect Personnel	\$53,800	\$67,250	\$1,318,100	\$527,240	\$82,332,544	\$67,250	\$1,318,100	\$527,240	\$82,332,544	\$67,250	\$1,318,100	\$527,240
Consumption	\$28,339,462	\$4,751,482	\$33,536,918	\$21,202,893	\$4,377,889,883	\$4,751,482	\$21,202,893	\$2,901,405	\$4,377,889,883	\$4,751,482	\$21,202,893	\$2,901,405
Direct maintenance	\$277,000	\$117,000	\$133,000	\$152,000	\$1,321,000	\$101,500	\$107,000	\$126,500	\$1,321,000	\$101,500	\$107,000	\$126,500
Modifications	\$277,000	\$117,000	\$133,000	\$152,000	\$1,321,000	\$101,500	\$107,000	\$126,500	\$1,321,000	\$101,500	\$107,000	\$126,500
Support equip replace	\$277,000	\$117,000	\$133,000	\$152,000	\$1,321,000	\$101,500	\$107,000	\$126,500	\$1,321,000	\$101,500	\$107,000	\$126,500
TOTAL OPERATE AND SUPPORT	\$129,487,744	\$35,846,990	\$135,517,499	\$62,291,525	\$4,746,376,042	\$33,118,292	\$104,673,969	\$43,913,537	\$4,746,376,042	\$33,118,292	\$104,673,969	\$43,913,537

DWF mission equipment due to the cost of the SS 4 mooring and fendering system and the extensive roadway to shore as required in that mission scenario.

For all of the systems, the personnel costs are among the highest. This is not at all surprising as labor costs usually constitute a significant portion of equipment O&S costs. Among the personnel costs, the S-T-S LOTS system at \$505M are higher than the next DWF LOTS system by a factor of 5.

The other significant O&S cost contributor in all missions is the cost of consumables. Though this cost includes the cost of maintenance material and replacement spares, the cost of POL is by far the largest contributor. For this reason the cost of consumables for the S-T-S LOTS system is again significantly greater than all the other systems. The large number of powered causeway sections, side loadable warping tugs, and other motorized equipment that comprise this system are responsible.

Looking at the totals for each mission it is evident that Mission 1 is the most expensive mission to perform for any system. This mission places the greatest stress and demands on personnel and equipment. Looking at the two systems compared in that mission, the S-T-S LOTS system with a cost of \$5,235M for 25 years of operating life is significantly greater than the \$106M for the DWF with its unsheltered environment equipment package. These costs differ by a factor of 50. Mission 3 (ALSB) is \$155M for the DWF and \$123M for the fixed pier. This represents a cost differential of less than \$50.0M over the anticipated 25 year life of both systems. Mission 2 (Prepositioning pier) costs about half of the ALSB because of the of peacetime utilization of the DWF by the host Nation.

Not included in the cost comparison is the cost of second destination transportation. When comparing the costs of a DWF

with that of a fixed pier, the cost differences were considered to be minimal. For the LOTS comparison the following would apply. It takes three heavy lift ships to transport the LOTS DWF and a 10,000 mile trip would take 28 days. Adding two days to load and one day to offload, with ship costs at \$50k/day, the estimated cost would be \$1550K. To transport the S-T-S LOTS equipment would take 5 LASH ships (Reference 8) and a 10000 mile trip would take 19 days. Adding five days to load and 4 days to offload, with ship costs at \$35k/day, the estimated costs would be \$978k. Within the size of the overall estimates, these differences are not significant.

2.8 ADVANTAGES AND DISADVANTAGES OF THE DWF VS. ITS ALTERNATIVES

Mission 1 LOTS, DWF vs. S-T-S

DWF Advantages:

- Lower initial cost and O&S costs.
- Lower support requirements.
- Good predicted RM&A characteristics.
- SS 4 capability.
- Versatile, multiple uses.
- Peacetime utility.
- More efficient cargo handling.

DWF Disadvantages:

- Complex transportation, relocation.
- Moderate development risk.
- Vulnerable to attack.

S-T-S System Advantages:

- Fully established and operating logistic support network.
- Transportation methods and equipment already developed.
- Rapid availability once in the objective area.

S-T-S System Disadvantages:

- Manpower intensive.
- Very high support requirements.
- Sea State limited.
- High O&S costs.

Missions 2, 3, and 4, DWF vs. Fixed Pier

DWF Advantages:

- Relocatable.
- Responsive to changes in political climate.
- Rapid availability in objective area.

DWF Disadvantages:

- Lower RM&A characteristics.
- Greater logistic support requirements.
- Moderate development risk.
- New training and support network to be established.

Fixed Pier Advantages:

- No new training required for any operations.
- Existing design, construction and maintenance experience.
- Lower initial cost.

Fixed Pier Disadvantages:

- May be abandoned because of changes in political climate or during a war.
- Long construction time.
- May be under utilized.

2.9 RISKS

There are few risks associated with the DWF development. The system relies heavily on existing technology. Very little research and development is required.

One of the areas in which there is some risk involved is in the development of a mooring system and fendering system that will permit operations to continue in SS4. These are required for Mission 1 only. The most critical of these is the mooring system for the DWF. As stated earlier, the three systems under consideration are:

- a. Tension anchor
- b. Pile restrained
- c. Jack-up

Of the three, the most promising from a stability standpoint is the jack-up mooring approach. There are currently two military systems that use this approach successfully, the DeLong Pier and the ELCAS. Both rely on similar hydraulic or pneumatically powered mechanisms for lifting the platform. Because of the greater size and weight of the DWF, the jacking system will probably require some modification. Along with a suitable mooring system, energy absorbing fenders will have to be

developed. These will likely be of the large foam filled or pneumatic type with tire and chain nets.

Another area of risk for the DWF is rapid transportability. There are approximately 17 heavy lift semi-submersible ships worldwide. They vary considerably in deck area and lifting capacity. It has been estimated (Reference 6) that two ships such as the AMERICAN CORMORANT will be required to rapidly deliver the DWF and all of its support equipment to any location around the world. The availability of these ships for lease or purchase by the U.S. Navy considering the political and economic factors, is unknown. The alternative of slow transport presents the risk of longer exposure to potential adverse action or weather.

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APPENDIX A
COST ANALYSIS
USED IN THE
COMPARATIVE ANALYSIS
OF THE
DEPLOYABLE WATERFRONT

TABLE A-1 Cost Summary for Deployable Waterfront Comparative Analysis

MISSIONS	DEPLOYABLE WATERFRONTS				S-T-S		FIXED PIERS	
	1 LOTS	2 PREPOSITION	3 ALSB	4 HOMEPORT	1 LOTS	2 PREPOSITION	3 ALSB	4 HOMEPORT
1.0 RTDR	\$25,000,000	\$1,000,000	\$11,100,000	\$9,700,000	\$0	\$0	\$0	\$0
2.0 INVESTMENT								
2.1 Direct Manufacture	\$55,400,000	\$23,400,000	\$26,600,000	\$30,400,000	\$264,200,000	\$20,300,000	\$21,400,000	\$25,300,000
2.2 Indirect	\$554,000	\$234,000	\$266,000	\$304,000	\$2,642,000	\$203,000	\$214,000	\$253,000
2.3 Initial Spares	\$1,662,000	\$702,000	\$798,000	\$912,000	\$7,926,000	\$609,000	\$642,000	\$759,000
2.4 Test & Support	\$55,400	\$23,400	\$26,600	\$30,400	\$264,200	\$20,300	\$21,400	\$25,300
2.0 TOTAL INVESTMENT	\$57,671,400	\$24,359,400	\$27,690,600	\$31,646,400	\$275,032,200	\$21,133,300	\$22,277,400	\$26,337,300
3.0 OPERATING AND SUPPORT								
3.01 Personnel								
3.011 Personnel	\$77,184,000	\$23,616,000	\$77,184,000	\$30,873,600	\$275,359,680	\$23,616,000	\$77,184,000	\$30,873,600
3.012 Replacement Training	\$23,078,016	\$7,061,184	\$23,078,016	\$9,231,206	\$6,823,185	\$7,061,184	\$23,078,016	\$9,231,206
3.013 Personnel Replacement	\$1,465	\$75	\$1,465	\$586	\$7,750	\$75	\$1,465	\$586
3.014 Indirect Personnel	\$53,800	\$67,250	\$1,318,100	\$527,240	\$82,332,544	\$67,250	\$1,318,100	\$527,240
3.02 Consumption	\$28,339,462	\$4,751,482	\$23,536,918	\$21,202,893	\$4,377,889,883	\$2,069,283	\$2,771,388	\$2,901,405
3.03 Direct maintenance	\$277,000	\$117,000	\$133,000	\$152,000	\$1,321,000	\$101,500	\$107,000	\$126,500
3.04 Modifications	\$277,000	\$117,000	\$133,000	\$152,000	\$1,321,000	\$101,500	\$107,000	\$126,500
3.05 Support equip replace	\$277,000	\$117,000	\$133,000	\$152,000	\$1,321,000	\$101,500	\$107,000	\$126,500
3.0 TOTAL OPERATE AND SUPPORT	\$129,487,744	\$35,846,990	\$135,517,499	\$62,291,525	\$4,746,376,042	\$33,118,292	\$104,673,969	\$43,913,537
GRAND TOTALS	\$212,159,144	\$61,206,390	\$174,308,099	\$103,637,925	\$5,021,408,242	\$54,250,592	\$126,951,369	\$70,250,837
MISSION 1: LOTS	\$212,159,144				\$5,021,408,242			
MISSION 2: PREPOSITION		\$61,206,390				\$54,250,592		
MISSION 3: ALSB			\$174,308,099				\$126,951,369	
MISSION 4: HOMEPORT				\$103,637,925				\$70,250,837

2.0 INVESTMENTS FOR DEPLOYABLE WATERFRONTS

2.0	DWF LOTS INVESTMENT Mission 1	
2.1	Direct Manufacture	\$55,400,000
2.2	Indirect 0.01*Direct	\$554,000
2.3	Initial Spares 0.03*Direct	\$1,662,000
2.4	Test & Support 0.001*Direct	\$55,400
2.0	TOTAL INVESTMENT	\$57,671,400
2.0	DWF PREPOSITIONED PIER INVESTMENT Mission 2	
2.1	Direct Manufacture	\$23,400,000
2.2	Indirect 0.01*Direct	\$234,000
2.3	Initial Spares 0.03*Direct	\$702,000
2.4	Test & Support 0.001*Direct	\$23,400
2.0	TOTAL INVESTMENT	\$24,359,400
2.0	DWF ALSB PIER INVESTMENT Mission 3	
2.1	Direct Manufacture	\$26,600,000
2.2	Indirect 0.01*Direct	\$266,000
2.3	Initial Spares 0.03*Direct	\$798,000
2.4	Test & Support 0.001*Direct	\$26,600
2.0	TOTAL INVESTMENT	\$27,690,600
2.0	DWF HOMEPORT PIER INVESTMENT Mission 4	
2.1	Direct Manufacture	\$30,400,000
2.2	Indirect 0.01*Direct	\$304,000
2.3	Initial Spares 0.03*Direct	\$912,000
2.4	Test & Support 0.001*Direct	\$30,400
2.0	TOTAL INVESTMENT	\$31,646,400
2.0	S-T-S LOTS INVESTMENT Mission 1	
	RO/RO INVESTMENT	\$11,200,000
	MELCAS INVESTMENT	\$72,000,000
	SLWT INVESTMENT	\$48,000,000
	CSP INVESTMENT	\$70,000,000
	CSNP INVESTMENT	\$63,000,000
2.1	Total Direct Manufacture	\$264,200,000
2.2	Indirect 0.01*Direct	\$2,642,000
2.3	Initial Spares 0.03*Direct	\$7,926,000
2.4	Test & Support 0.001*Direct	\$264,200
	TOTAL S-T-S LOTS INVESTMENT	\$275,032,200

2.0	FIXED PREPOSITIONED PIER INVESTMENT	Mission 2	
2.1	Direct Manufacture		\$20,300,000
2.2	Indirect 0.01*Direct		\$203,000
2.3	Initial Spares 0.03*Direct		\$609,000
2.4	Test & Support 0.001*Direct		\$20,300
2.0	TOTAL INVESTMENT		\$21,132,300
2.0	FIXED ALSB PIER INVESTMENT	Mission 3	
2.1	Direct Manufacture		\$21,400,000
2.2	Indirect 0.01*Direct		\$214,000
2.3	Initial Spares 0.03*Direct		\$642,000
2.4	Test & Support 0.001*Direct		\$21,400
2.0	TOTAL INVESTMENT		\$22,277,400
2.0	FIXED HOMEPORT PIER INVESTMENT	Mission 4	
2.1	Direct Manufacture		\$25,300,000
2.2	Indirect 0.01*Direct		\$253,000
2.3	Initial Spares 0.03*Direct		\$759,000
2.4	Test & Support 0.001*Direct		\$25,300
2.0	TOTAL INVESTMENT		\$26,337,300

DEPLOYABLE WATERFRONT LIFE CYCLE COST SCENARIOS

3.0 O & S COSTS FOR LOTS OPERATIONS

3.011 Personnel ops. LOTS DWF

Function	Unit	Month	Day/ month	Men	MY	Hr/day	\$/man hr	Total
Peace/Ops	1	294	15	100	2450	8	\$8	\$28,224,000
/maint	1	294	15	100	2450	8	\$8	\$28,224,000
Sub total					4900			
War/ops	1	6	30	400	200	20	\$12	\$17,280,000
War/maint	1	6	30	400	200	4	\$12	\$3,456,000
Sub total					400			\$77,184,000

3.012 Replacement Training
Peacetime ops and training \$* 0.299 \$23,078,016

3.013 Personnel replacement
Peacetime ops and training M* 0.299 \$1,465

3.014 Indirect Personnel
Peacetime ops and training M* 269 \$53,800

3.01 TOTAL LOTS DWF \$100,317,281

3.011 Personnel PREPOSITIONED PIER DWF

Function	Unit	Month	Day/ month	Men	MY	Hr/day	\$/man hr	Total
Peace/Ops	1	15	15	100	125	8	\$8	\$1,440,000
/maint	1	15	15	100	125	8	\$8	\$1,440,000
Sub total					250			
War/ops	1	6	30	400	200	20	\$12	\$17,280,000
War/maint	1	6	30	400	200	4	\$12	\$3,456,000
Sub total					400			\$23,616,000

3.012 Replacement Training
Peacetime ops and training \$* 0.299 \$7,061,184

3.013 Personnel replacement
Peacetime ops and training M* 0.299 \$75

3.014 Indirect Personnel
Peacetime ops and training M* 269 \$67,250

3.01 TOTAL PREPOSITIONED PIER DWF \$30,744,509

3.011 Personnel ALSB DWF

Function	Unit	Month	Day/ month	Men	MY	Hr/day	\$/man hr	Total
Peace/Ops	1	294	15	100	2450	8	\$8	\$28,224,000
/maint	1	294	15	100	2450	8	\$8	\$28,224,000
Sub total					4900			
War/ops	1	6	30	400	200	20	\$12	\$17,280,000
War/maint	1	6	30	400	200	4	\$12	\$3,456,000
Sub total					400			\$77,184,000

3.012 Replacement Training

Peacetime ops and training \$* 0.299 \$23,078,016

3.013 Personnel replacement

Peacetime ops and training M* 0.299 \$1,465

3.014 Indirect Personnel

Peacetime ops and training M* 269 \$1,318,100

3.01 TOTAL ALSB

\$101,581,581

3.011 Personnel HOMEPORT DWF

Function	Unit	Month	Day/ month	Men	MY	Hr/day	\$/man hr	Total
Peace/Ops	1	294	15	40	980	8	\$8	\$11,289,600
/maint	1	294	15	40	980	8	\$8	\$11,289,600
Sub total					1960			
War/ops	1	6	30	160	80	20	\$12	\$6,912,000
War/maint	1	6	30	160	80	4	\$12	\$1,382,400
Sub total					160			\$30,873,600

3.012 Replacement Training

Peacetime ops and training \$* 0.299 \$9,231,206

3.013 Personnel replacement

Peacetime ops and training M* 0.299 \$586

3.014 Indirect Personnel

Peacetime ops and training M* 269 \$527,240

3.01 TOTAL HOMEPORT

\$40,632,632

DEPLOYABLE WATERFRONT LIFE CYCLE COST SCENARIOS

3.0 O & S COSTS FOR S-T-S LOTS OPERATIONS

3.011 Personnel ops. RO/RO

Function	Unit	Month	Day/ month	Men	MY	Hr/day	\$/man hr	Total
Maint/stow	2	294	2	4	196	8	\$15	\$564,480
Peace/Ops	1	294	15	8	196	8	\$8	\$2,257,920
/maint	1	294	15	8	196	8	\$8	\$2,257,920
Sub total					588			
War/ops	4	6	30	16	32	20	\$12	\$2,764,800
War/maint	4	6	30	16	32	4	\$12	\$552,960
Sub total					64			\$8,398,080

3.012 Replacement Training RO/RO

Peacetime ops and training \$* 0.299 \$2,511,026

3.013 Personnel replacement

Peacetime ops and training MY* 0.299 \$176

3.014 Indirect Personnel

Peacetime ops and training MY* 269 \$8,608

TOTAL RO/RO \$10,917,890

3.011 Personnel LOTS ops. ELCAS

Function	Unit	Month	Day/ month	Men	MY	Hr/day	\$/man hr	Total
Maint/stow	2	294	2	20	980	8	\$15	\$2,822,400
Peace/Ops	1	294	15	50	1225	8	\$8	\$14,112,000
/maint	1	294	15	50	1225	8	\$8	\$14,112,000
Sub total					3430			
War/ops	3	6	30	100	150	20	\$12	\$12,960,000
War/maint	3	6	30	100	150	4	\$12	\$2,592,000
Sub total					300			\$46,598,400

3.012 Replacement Training

Peacetime ops and training \$* 0.299 \$13,932,922

3.013 Personnel replacement

Peacetime ops and training MY* 0.299 \$1,026

3.014 Indirect Personnel

Peacetime ops and training MY* 269 \$922,670

TOTAL ELCAS \$61,455,017

3.011 Personnel LOTS ops. SLWT

Function	Unit	Month	Day/ month	Men	MY	Hr/day	\$/man hr	Total
Maint/stow	10	294	2	5	1225	8	\$15	\$3,528,000
Peace/Ops	12	294	15	3	882	8	\$8	\$10,160,640
/maint	12	294	15	4	1176	8	\$8	\$13,547,520
Sub total					3283			
War/ops	22	6	30	6	66	20	\$12	\$5,702,400
War/maint	22	6	30	8	88	4	\$12	\$1,520,640
Sub total					154			\$34,459,200

3.012 Replacement Training
Peacetime ops and training \$* 0.299 \$10,303,301

3.013 Personnel replacement
Peacetime ops and training MY* 0.299 \$982

3.014 Indirect Personnel
Peacetime ops and training MY* 269 \$883,127

TOTAL SLWT \$45,646,609

3.011 Personnel LOTS ops. CSP

Function	Unit	Month	Day/ month	Men	MY	Hr/day	\$/man hr	Total
Maint/stow	20	294	2	10	4900	8	\$15	\$14,112,000
Peace/Ops	20	294	15	5	2450	8	\$8	\$28,224,000
/maint	20	294	15	5	2450	8	\$8	\$28,224,000
Sub total					9800			
War/ops	40	6	30	10	200	20	\$12	\$17,280,000
War/maint	40	6	30	10	200	4	\$12	\$3,456,000
Sub total					400			\$91,296,000

3.012 Replacement Training
Peacetime ops and training \$* 0.299 \$27,297,504

3.013 Personnel replacement
Peacetime ops and training MY* 0.299 \$2,930

3.014 Indirect Personnel
Peacetime ops and training MY* 269 \$2,636,200

TOTAL CSP \$121,232,634

3.011 Personnel LOTS ops. CSNP

Function	Unit	Month	Day/ month	Men	MY	Hr/day	\$/man hr	Total
Maint/stow	90	294	2	2	4410	8	\$15	\$12,700,800
Peace/Ops	90	294	15	0	0	8	\$8	\$0
/maint	90	294	15	2	4410	8	\$8	\$50,803,200
Sub total					8820			
War/ops	180	6	30	0	0	20	\$12	\$0
War/maint	180	6	30	4	360	20	\$12	\$31,104,000
Sub total					360			\$94,608,000

3.012 Replacement Training

Peacetime ops and training \$* 0.299 \$28,287,792

3.013 Personnel replacement

Peacetime ops and training MY* 0.299 \$2,637

3.014 Indirect Personnel

Peacetime ops and training MY* 269 \$2,372,580
TOTAL CSNP \$125,271,009

3.011 PERSONNEL	\$275,359,680
3.012 REPLACEMENT TRAINING	\$6,823,185
3.013 PERSONNEL REPLACEMENT	\$7,750
3.013 INDIRECT PERSONNEL	\$82,332,544
3.01 TOTAL FOR S-T-S LOTS PERSONNEL	\$364,523,160

3.011 Personnel FIXED HOMEPORT PIER

Function	Unit	Month	Day/ month	Men	MY	Hr/day	\$/man hr	Total
Peace/Ops	1	294	15	40	980	8	\$8	\$11,289,600
/maint	1	294	15	40	980	8	\$8	\$11,289,600
Sub total					1960			
War/ops	1	6	30	160	80	20	\$12	\$6,912,000
War/maint	1	6	30	160	80	4	\$12	\$1,382,400
Sub total					160			\$30,873,600

3.012 Replacement Training

Peacetime ops and training \$0.299 \$9,231,206

3.013 Personnel replacement

Peacetime ops and training M0.299 \$586

3.014 Indirect Personnel

Peacetime ops and training M 269 \$527,240

3.01 TOTAL FIXED HOMEPORT PIER \$40,632,632

3.011 Personnel FIXED PREPO PIER

Function	Unit	Month	Day/ month	Men	MY	Hr/day	\$/man hr	Total
Peace/Ops	1	15	15	100	125	8	\$8	\$1,440,000
/maint	1	15	15	100	125	8	\$8	\$1,440,000
Sub total					250			
War/ops	1	6	30	400	200	20	\$12	\$17,280,000
War/maint	1	6	30	400	200	4	\$12	\$3,456,000
Sub total					400			\$23,616,000

3.012 Replacement Training
Peacetime ops and training \$* 0.299 \$7,061,184

3.013 Personnel replacement
Peacetime ops and training M* 0.299 \$75

3.014 Indirect Personnel
Peacetime ops and training M* 269 \$67,250

TOTAL FIXED PREPO PIER \$30,744,509

3.011 Personnel FIXED ALSB PIER

Function	Unit	Month	Day/ month	Men	MY	Hr/day	\$/man hr	Total
Peace/Ops	1	294	15	100	2450	8	\$8	\$28,224,000
/maint	1	294	15	100	2450	8	\$8	\$28,224,000
Sub total					4900			
War/ops	1	6	30	400	200	20	\$12	\$17,280,000
War/maint	1	6	30	400	200	4	\$12	\$3,456,000
Sub total					400			\$77,184,000

3.012 Replacement Training
Peacetime ops and training \$* 0.299 \$23,078,016

3.013 Personnel replacement
Peacetime ops and training M* 0.299 \$1,465

3.014 Indirect Personnel
Peacetime ops and training M* 269 \$1,318,100

TOTAL FIXED ALSB PIER \$101,581,581

CONSUMABLES FOR DWF

3.02 LOTS DWF CONSUMABLES for INVESTMENT \$55.4m \$55,400,000

Fuel	#	Eng	#hrs	Gal/hr	\$/gal	
		40	74800	7.5	1	\$22,464,000

Eng oil	#	Eng	hr/25	Gal/ch	\$/gal	
		40	299.	7	4	\$335,462

Maint mat	0.05*Manf costs	\$2,770,000
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Repl spare	0.05*Manf costs	\$2,770,000
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3.02	TOTAL	\$28,339,462
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3.03	Direct Depot Maintance = 0.005 Manf costs	\$277,000
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3.04	Modifications = 0.005 Manf costs	\$277,000
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3.05	Support equip repl = 0.005 Manf costs	\$277,000
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3.02 - 3.05	TOTAL for LOTS DWF	\$29,170,462
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3.02 PREPOSITIONED DWF CONSUMABLES @ INVESTMENT \$23.4M \$23,400,000

Fuel	#	Eng	#hrs	Gal/hr	\$/gal	
		40	79200	7.5	1	\$2,376,000

Eng oil	#	Eng	hr/25	gal/ch	\$/gal	
		40	31.6	7	4	\$35,482

Maint mat	0.05*Manf costs	\$1,170,000
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Repl spare	0.05*Manf costs	\$1,170,000
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3.02	TOTAL	\$4,751,482
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3.03	Direct Depot Maintance = 0.005 Manf costs	\$117,000
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3.04	Modifications = 0.005 Manf costs	\$117,000
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3.05	Support equip repl = 0.005 Manf costs	\$117,000
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3.02 - 3.05	TOTAL for PREPOSITIONED DWF	\$5,102,482
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3.02	ALSB	DWF CONSUMABLES for INVESTMENT \$26.6M	\$26,600,000
Fuel	# Eng	#hrs Gal/hr \$/gal	
	68	74800 6 1	\$30,551,040
Eng oil	# Eng	hr/25 gal/ch \$/gal	
	68	299 4 4	\$325,878
Maint mat	0.05*Manf costs		\$1,330,000
Repl spare	0.05*Manf costs		\$1,330,000
3.02	TOTAL		\$33,536,918
3.03	Direct Depot Maintance = 0.005 Manf costs		\$133,000
3.04	Modifications = 0.005 Manf costs		\$133,000
3.05	Support equip repl = 0.005 Manf costs		\$133,000
3.02 - 3.05	TOTAL for ALSB DWF		\$33,935,918

3.02	HOMEPORT	DWF CONSUMABLES for INVESTMENT \$30.4	\$30,400,000
Fuel	# Eng	#hrs Gal/hr \$/gal	
	40	74800 6 1	\$17,971,200
Eng oil	# Eng	hr/25 gal/ch \$/gal	
	40	299 4 4	\$191,693
Maint mat	0.05*Manf costs		\$1,520,000
Repl spare	0.05*Manf costs		\$1,520,000
3.02	TOTAL		\$21,202,893
3.03	Direct Depot Maintance = 0.005 Manf costs		\$152,000
3.04	Modifications = 0.005 Manf costs		\$152,000
3.05	Support equip repl = 0.005 Manf costs		\$152,000
3.02 - 3.05	TOTAL for HOMEPORT DWF		\$21,658,893

CONSUMABLES FOR S-T-S LOTS

3.02 RO/RO CONSUMABLES for INVESTMENT 7*\$1.6m \$11,200,000

Fuel	#	Eng	#hrs	Gal/hr	\$/gal	
		2	49000	1	1	\$141,010

Eng oil	#	Eng	hr/250	gal/ch	\$/gal	
		2	389	2	4	\$6,224

Maint mat 0.05*Manf costs \$560,000

Repl spare0.05*Manf costs \$560,000

3.03 Direct Depot Maintance = 0.005 Manf costs \$56,000

3.04 Modifications = 0.005 Manf costs \$56,000

3.05 Support equip repl = 0.005 Manf costs \$56,000

3.02 ELCAS CONSUMABLES for INVESTMENT 4.5*\$16.0m \$72,000,000

Fuel	#	Eng	#hrs	Gal/hr	\$/gal	
		6	989000	10	1	\$61,701,120

Eng oil	#	Eng	hr/100	gal/ch	\$/gal	
		6	3955	5	4	\$427,162

Maint mat 0.05*Manf costs \$3,600,000

Repl spare0.05*Manf costs \$3,600,000

3.03 Direct Depot Maintance = 0.005 Manf costs \$360,000

3.04 Modifications = 0.005 Manf costs \$360,000

3.05 Support equip repl = 0.005 Manf costs \$360,000

3.02 SLWT CONSUMABLES for INVESTMENT 40*\$1.2m \$48,000,000

Fuel	#	Eng	#hrs	Gal/hr	\$/gal	
		44	989000	24	1	\$1,039,822,080

Eng oil	#	Eng	hr/100	gal/ch	\$/gal	
		44	10000	6	4	\$10,006,656

Maint mat 0.05*Manf costs \$2,400,000

Repl spare0.05*Manf costs \$2,400,000

3.03 Direct Depot Maintance = 0.005 Manf costs \$240,000

3.04 Modifications = 0.005 Manf costs \$240,000

3.05 Support equip repl = 0.005 Manf costs \$240,000

3.02 CSP	CONSUMABLES for INVESTMENT 70*	\$1.0m	\$70,000,000
Fuel	# Eng #hrs Gal/hr \$/gal		
	80 1678000 24 1		\$3,208,488,960
Eng oil	# Eng hr/100 gal/ch \$/gal		
	80 17000 6 4		\$30,876,672
Maint mat	0.05*Manf costs		\$3,500,000
Repl spare	0.05*Manf costs		\$3,500,000
3.03 Direct Depot Maintance	= 0.005 Manf costs		\$350,000
3.04 Modifications	= 0.005 Manf costs		\$350,000
3.05 Support equip repl	= 0.005 Manf costs		\$350,000
3.02 CSNP	CONSUMABLES for INVESTMENT 315*	\$0.2m	\$63,000,000
Fuel	# Eng #hrs Gal/hr \$/gal		\$0
Eng oil	# Eng hr/100 gal/ch\$/gal		\$0
Maint mat	0.05*Manf costs		\$3,150,000
Repl spare	0.05*Manf costs		\$3,150,000
3.03 Direct Depot Maintance	= 0.005 Manf costs		\$315,000
3.04 Modifications	= 0.005 Manf costs		\$315,000
3.05 Support equip repl	= 0.005 Manf costs		\$315,000
GRAND TOTALS			
3.02 TOTAL S-T-S LOTS CONSUMABLES			\$4,377,889,883
3.03 TOTAL DIR DEP MAIN			\$1,321,000
3.04 TOTAL MODS			\$1,321,000
3.05 TOTAL SUPP EQUIP REPLACE			\$1,321,000

3.02 FIXED PREPO PIER CONSUMABLES @ INVESTMENT \$20.3M \$20,300,000

Fuel	# Eng	#hrs	Gal/hr	\$/gal	
	40	79200	6	1	\$19,008

Eng oil	# Eng	hr/25	gal/ch	\$/gal	
	40	31.6	4	4	\$20,275

Maint mat 0.05*Manf costs \$1,015,000

Repl spare 0.05*Manf costs \$1,015,000

3.02 TOTAL \$2,069,283

3.03 Direct Depot Maintance = 0.005 Manf costs \$101,500

3.04 Modifications = 0.005 Manf costs \$101,500

3.05 Support equip repl = 0.005 Manf costs \$101,500

3.02 - 3.05 TOTAL for FIXED PREPO PIER \$2,373,783

3.02 FIXED ALSB PIER CONSUMABLES @ INVESTMENT \$21.4M \$21,400,000

Fuel	# Eng	#hrs	Gal/hr	\$/gal	
	68	74800	6	1	\$305,510

Eng oil	# Eng	hr/25	gal/ch	\$/gal	
	68	299	4	4	\$325,878

Maint mat 0.05*Manf costs \$1,070,000

Repl spare 0.05*Manf costs \$1,070,000

3.02 TOTAL \$2,771,388

3.03 Direct Depot Maintance = 0.005 Manf costs \$107,000

3.04 Modifications = 0.005 Manf costs \$107,000

3.05 Support equip repl = 0.005 Manf costs \$107,000

3.02 - 3.05 TOTAL for FIXED ALSB PIER \$3,092,388

3.02	FIXED HOMEPORT PIER CONSUMABLES @ INVESTMENT	\$25.	\$25,300,000
Fuel	# Eng #hrs Gal/hr \$/gal		
	40 74800 6 1		\$179,712
Eng oil	# Eng hr/25 gal/ch \$/gal		
	40 299 4 4		\$191,693
Maint mat	0.05*Manf costs		\$1,265,000
Repl spare	0.05*Manf costs		\$1,265,000
3.02	TOTAL		\$2,901,405
3.03	Direct Depot Maintance = 0.005 Manf costs		\$126,500
3.04	Modifications = 0.005 Manf costs		\$126,500
3.05	Support equip repl = 0.005 Manf costs		\$126,500
3.02 - 3.05	TOTAL for FIXED HOMEPORT PIER		\$3,280,905

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